Simulation Study of the PHENIX Silicon Vertex Detector Upgrade Expected Performance

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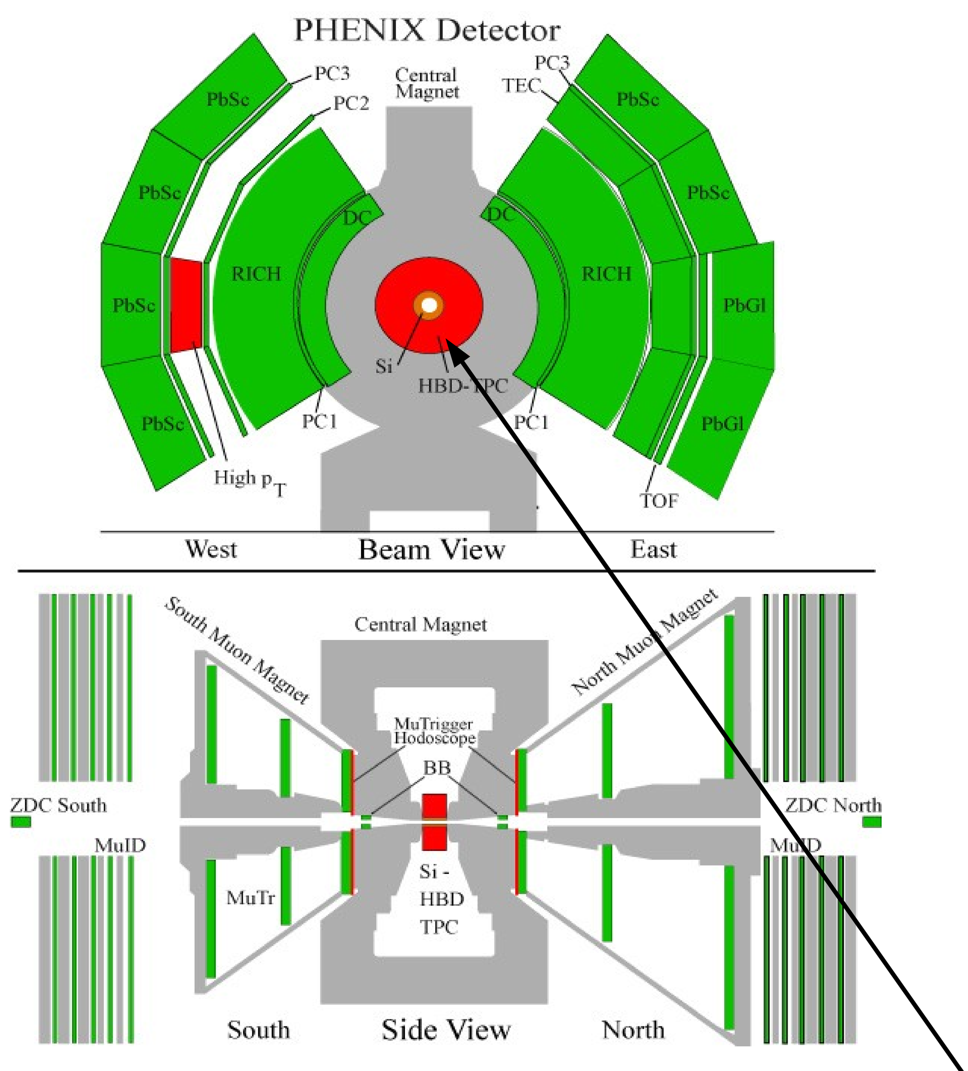
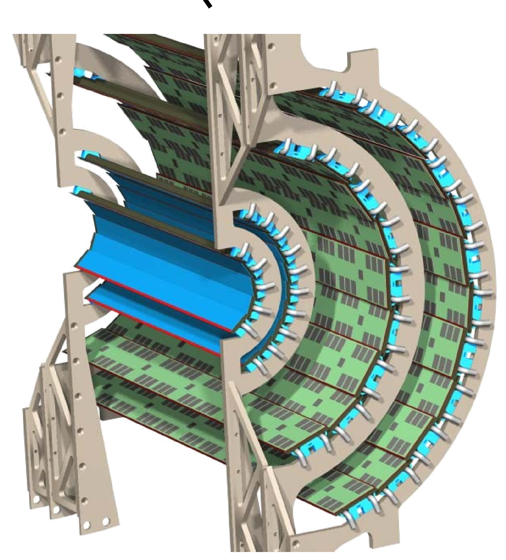
PHENIX

Introduction

PHENIX (Pioneering High Energy Nuclear Interaction eXperiment) is one of the two large experiments at the Relativistic Heavy Ion Collider (RHIC) located at the Brookhaven National Laboratory (BNL) on Long Island, New York.



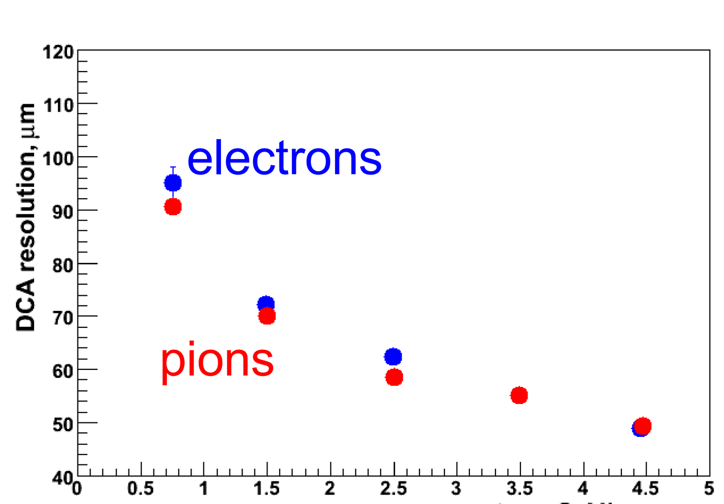
The Slicon Vertex Detector Upgrade (VTX) to the PHENIX detector will be installed in 2010, and will expand the physics capabilities of the PHENIX experiment. The upgrade will also improve the accuracy of previous measurements.
Among main goals of the VTX upgrade is to allow separation of charm and bottom contributions to the electron continuum, and allow direct D and B meson measurements. These goals will be achieved by measuring Distance of Closest Approach to the vertex (DCA) for charged tracks.



Motivation and Simulation Details

Heavy quarks are an important probe in studying heavy ion collisions. Because of their large mass, charm and bottom are only produced in the initial hard scattering and are sensitive to the entire evolution of the colliding system. Being able to measure charm and bottom contributions separately will allow us to distinguish between various theoretical models describing the medium, such as energy loss models.

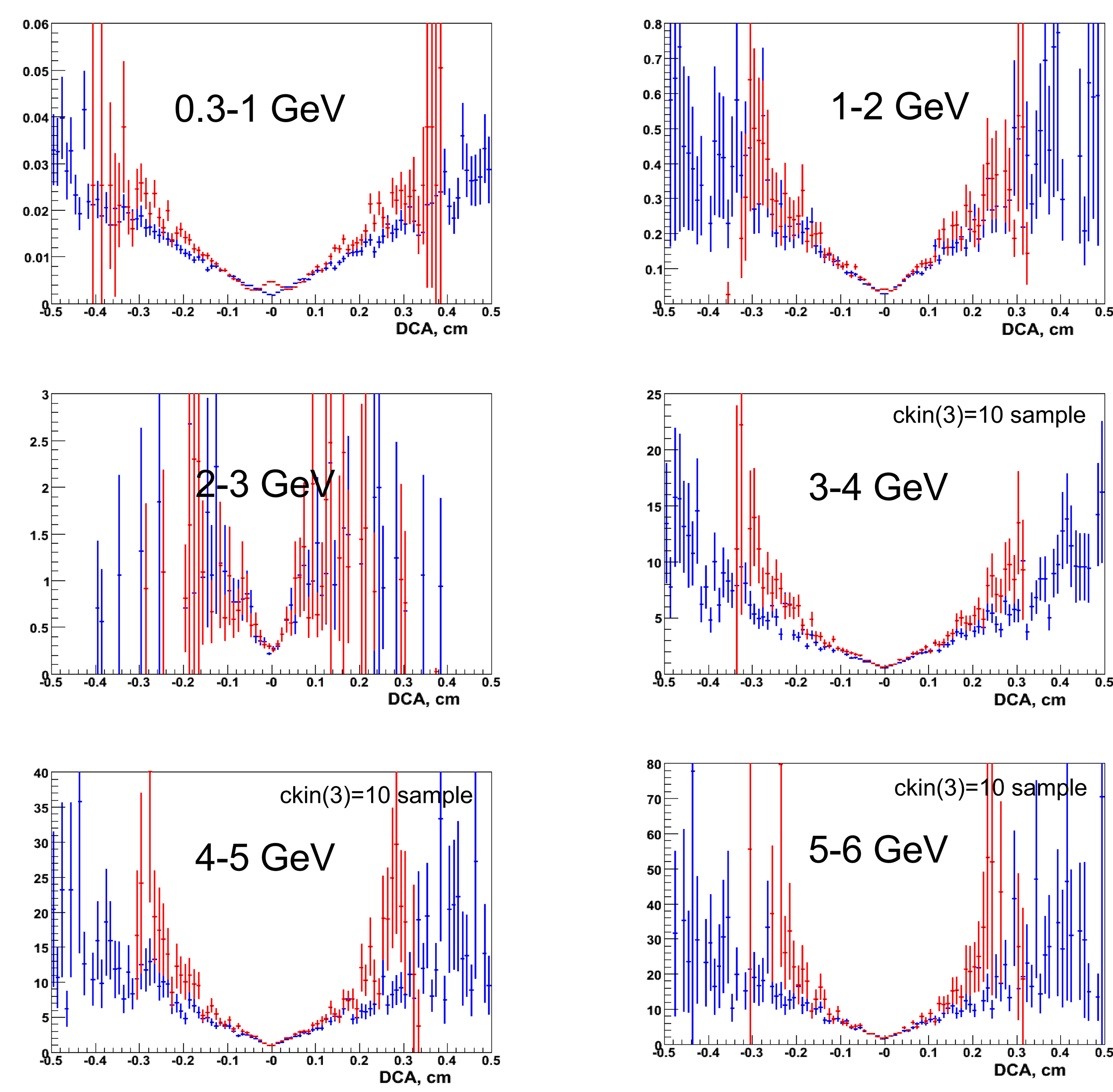
D and B mesons were generated using PYTHIA, and PYTHIA was also used for background simulation for D^0 to $K+\pi$ study. Two simulated data samples were used. One was from minimum bias PYTHIA events, the other one was produced with ckin(3)=10 in order to study high transverse momentum range with good statistics. Generated events were processed through full PHENIX simulation and reconstruction analysis chain.



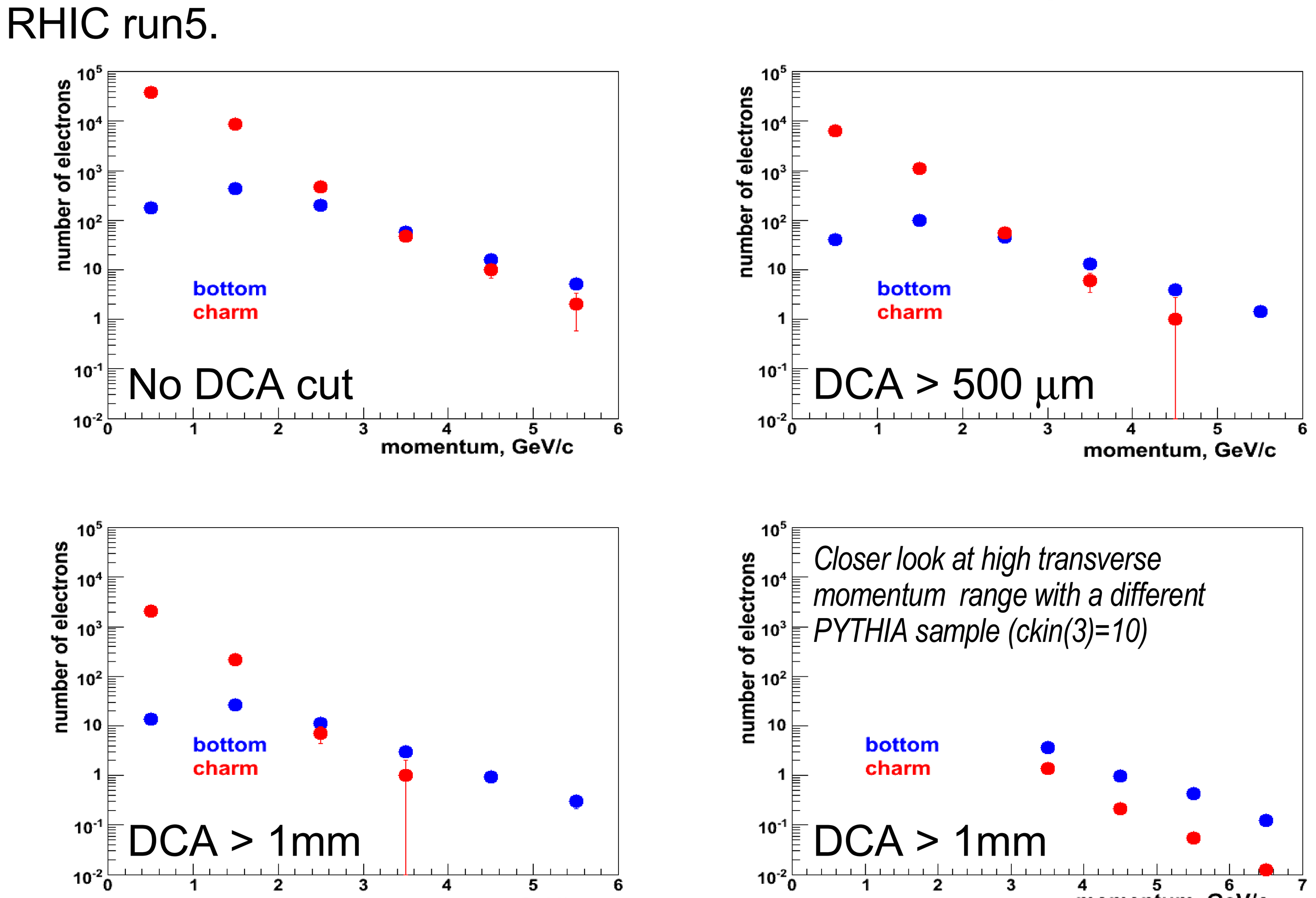
The plot on left shows DCA resolution obtained using full PHENIX simulation and reconstruction of single electrons and pions. This resolution can be further improved by applying χ^2 cut on charged tracks. This, however, will result in lower reconstruction efficiency.

Separation of charm and bottom in semi-leptonic channel using DCA measurement

D and B mesons have different life times, and, as a result, their tracks should have different Distance of Closest Approach (DCA) to the event vertex. By measuring DCA for electrons and selecting large DCAs, we can, first, remove background electrons from Dalitz decays and photon conversions, and, second, separate charm and bottom contributions to the single electron spectra.
The plots below show bottom/charm ratio vs DCA calculated using straight line projections from VTX clusters in two inner pixel layers (**red points**).
For comparison, **blue points** show DCA calculated from MC information, which correspond to a perfect detector case.



The plots below show expected electron yield from B and D mesons for 1.7B minimum bias p+p events, or ~1% of data taken by PHENIX during RHIC run5.

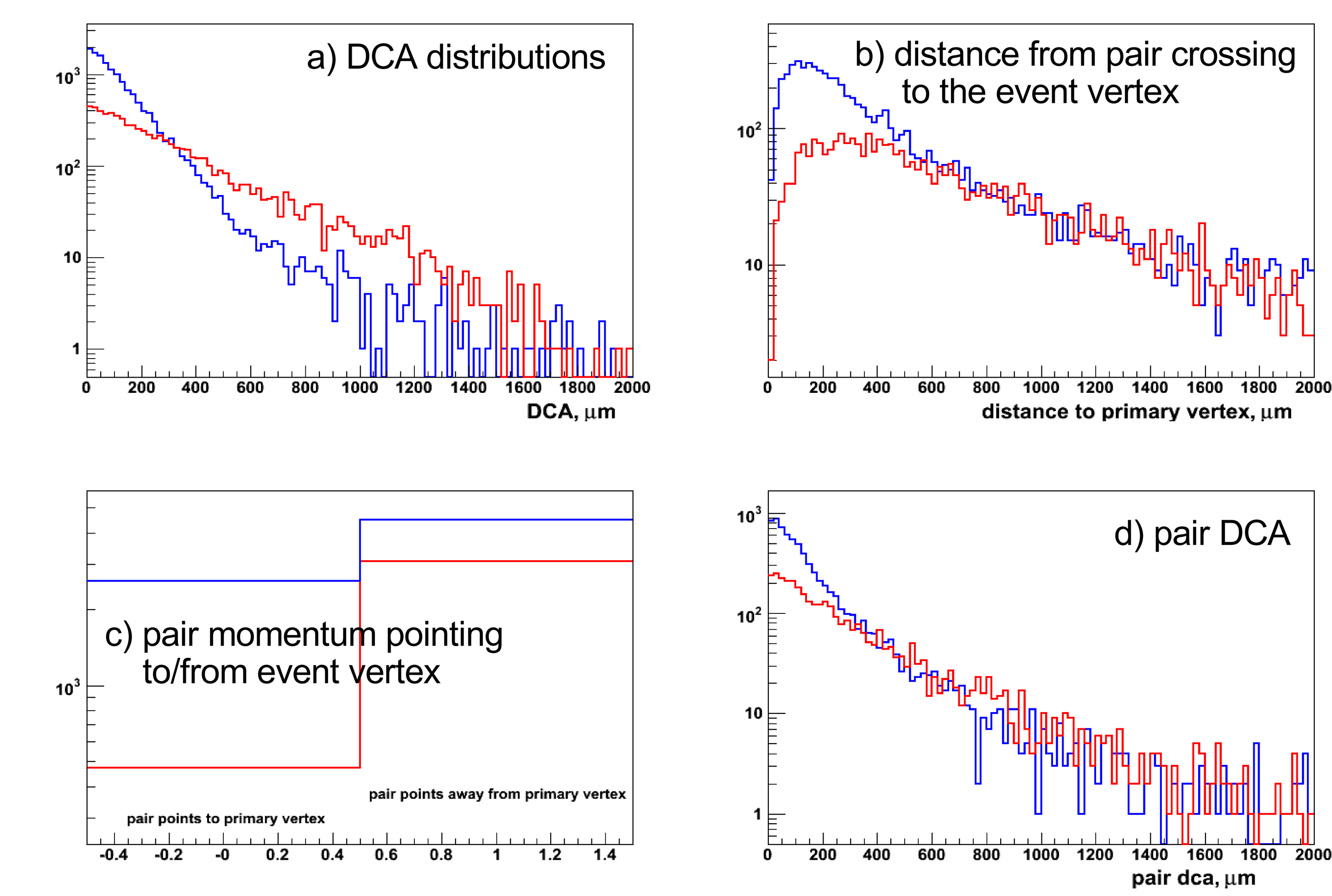


Direct measurement of open charm (D^0 mesons)

The main problem of direct measurement of D^0 and B^0 mesons in $K+\pi$ decay mode is very large combinatorial background. Using DCA measurement this background can be significantly reduced.
Different ways of reducing backgrounds are:

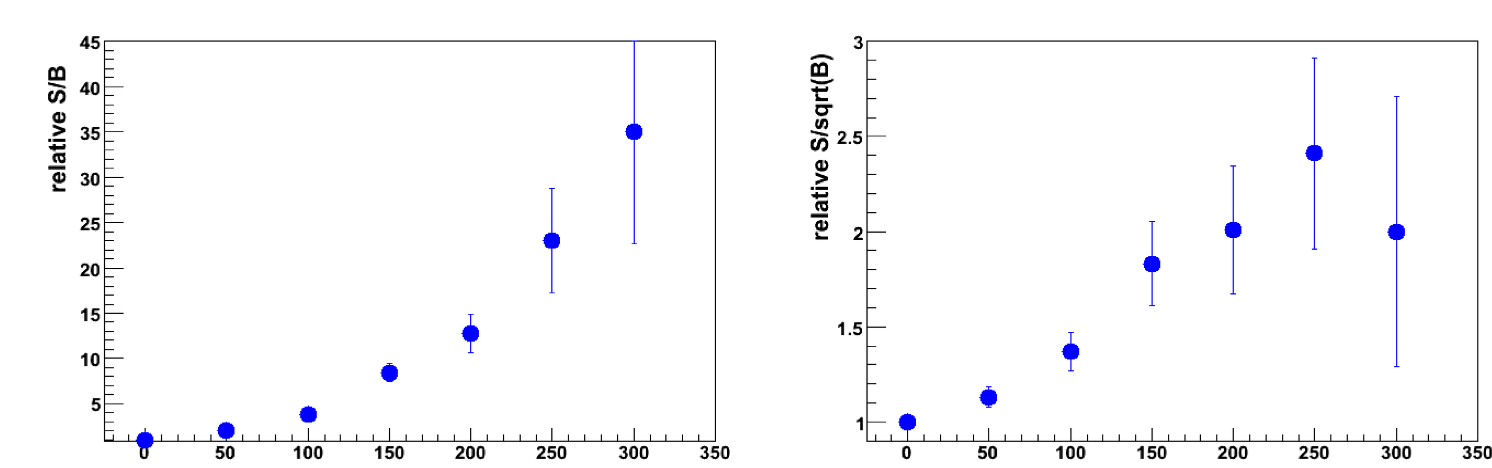
a) Require large DCA for both particles in the pair.
b) Require large distance between pair crossing point to the event vertex.
c) Require that pair momentum points away from the vertex.
d) Require small pair DCA.

The plots below show relevant distributions for D^0 mesons in **red**, and for combinatorial background from PYTHIA p+p events in **blue**.



Our study indicates that the best background reduction is provided by DCA cut on both particles in the pair (a), plus requiring that the pair momentum points away from the vertex (c).

Relative improvement in signal/background (S/B) and S/sqrt(B) ratios as a function of DCA cut on two particles, plus requirement that the pair momentum points away from the event vertex are shown below.



Conclusions

PHENIX experiment will be upgraded with the Silicon Vertex Detector Upgrade (VTX) in 2010.

This simulation study shows that VTX upgrade will allow to separate charm and bottom contribution to the single electron spectra, and improve signal/background ratio for D^0 meson measurement.

If you want to know more about Silicon Vertex Detector Upgrade for the PHENIX experiment, see also posters by Maki Kurosawa and Richard Petti